Open Journal of Clinical & Medical Images

www.jclinmedimages.org

Research Article

Open Access, Volume 2

Trends in medical artificial intelligence publications from 2000-2020: Where does radiology stand?

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Received: Jun 17, 2022

Accepted: Jul 18, 2022

Published: Jul 25, 2022

Archived: www.jclinmedimages.org

Introduction

Radiology is often identified as a field well-suited for AI integration due to its intimate relationship with informatics and reliance on digital imaging, but applications of medical AI are not limited to radiology. Submissions of AI tools for FDA approval have increased each year since 2012, and although the majority are radiology related, there are over 100 patents of FDA approved algorithms with applications in Pathology, Internal Medicine, Cardiology, Hematology, General Surgery, Orthopedics, and Ophthalmology [1,2].

While there was once concern in the radiology community that AI would lead to their replacement, the conversation has shifted in recent years from fear to optimism [3]. As familiarity with the strengths and shortcomings of clinical AI has increased, the radiology community now sees AI as a tool that will allow physicians to provide faster and safer patient care. The broader medical community has begun to take notice of the value of clinical AI, as well. In 2020, the Centers for Medicare & Medicaid Services (CMS), established a new Current Procedural Terminology code for an AI tool for the diagnosis of diabetic retinopathy, IDx-RX [4], prompting conversations on the potential of AI technologies to bring subspecialist level care to low resource communities [5].

Artificial intelligence (AI) is a burgeoning tool that will impact the practice of medicine across specialties. Bibliometric analysis can provide insight into how interest in a topic changes over time. Using MeSH terms and publication data from PubMed is a well described method for publication trend studies using academic medical journals [6-8]. Publication trend analysis of the radiology literature demonstrated exponential growth in AI in radiology since 2000 [9], but less is known about the growth of AI in other medical specialties. To assess the trends in AI by

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medical specialty, we performed a bibliometric analysis of medical AI research from 2000-2020.

Methods

Publication searches were performed using the PubMed database. From 2000 to 2020, all artificial intelligence (AI)-related publications were selected by using the following MeSH terms: Artificial Intelligence, Neural Networks, Machine Learning, Deep Learning, Support Vector Machine, Bayesian Analysis, Cluster Analysis, and Principal Component Analysis. Specialty-specific artificial intelligence research was selected by combining the MesH terms with the specialty name. Twenty-three specialties were selected from the ERAS specialty list. Special consideration was taken for the query of specialties with alternate British spelling, such as paediatrics and orthopaedic surgery, as well as making a distinction between "Pediatrics" and "Internal Medicine/Pediatrics". Search strings that would produce overlapping results, such as Medical Pediatrics with the query "medicine AND (pediatrics OR paediatrics)," were excluded.

The data was extracted using NCBI's EDirect software. Following the release of a new version of PubMed, the results returned by E-utilities queries of PubMed may be inaccurate. To correct for this, queries were entered manually and the resulting PMIDs were downloaded directly from the PubMed website to be used with EDirect. The resulting publication database was then categorized by journal, country of origin, publication year, funding agencies, and publication type.

Linear and non-linear regression were used to determine publication trends and an analysis of the citation statistics was performed using the student's T-test to compare means.

Results

In the 22 medical specialties evaluated, our bibliometric study extracted 74,079 total AI articles published between 2000-2020. The overall trend in AI publications showed exponential increase in AI publications from 2000-2020 (Figure 1.; R^2 = 0.97). Pathology (20,970), Radiology (10,922), and Psychiatry (4,829) were the highest producers of AI publications with Pathology and Radiology occupying 28.3% and 14.7% of the total respectively. Dermatology (804), ENT (647), and Plastic Surgery (265) had the lowest number of AI publications. The countries with the most prolific AI research publications were the United States (36,266), England (18,171), and the Netherlands (5361).

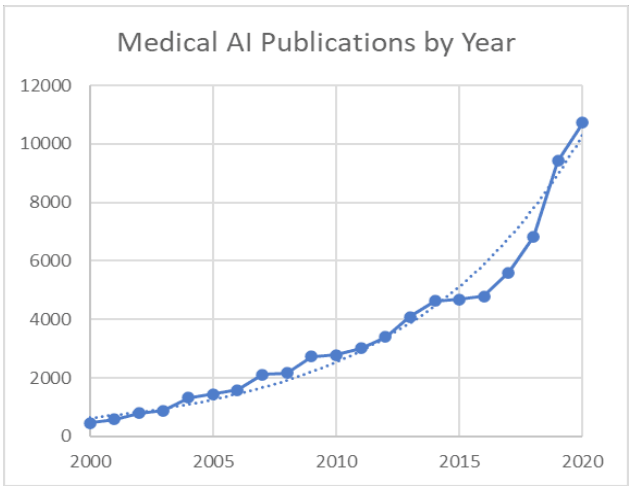

Figure 1: Total number of AI publications by year (solid line) and trend line (dotted line) showing exponential growth from 2000-2020 (R^2=0.97).

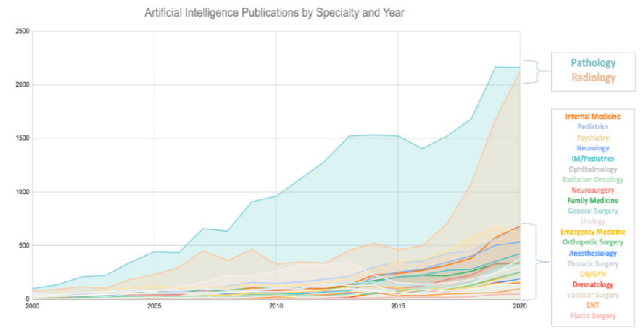

Figure 2: Total number of AI publications by specialty and year.

Table 1: Total number of AI publications produced from 2000-2020 by 10 countries with the highest number of publications.

United States	36266
England	18171
Netherlands	5361
Germany	4657
Switzerland	1867
Ireland	1341
Greece	853
China	551
Italy	513
Japan	447

Discussion

Medical AI publications have increased exponentially across medical subspecialties from 2000-2020. Pathology had the highest number of AI publications overall and also had the highest number each year. Radiology had the second highest number of publications overall and the second highest each year but demonstrated the most rapid growth, with an exponential increase in publications from 2015 to 2020. While Pathology and Radiology led the field in AI publication, representing over half of the total medical AI articles, all of the evaluated medical specialties demonstrated growth in AI publications during the study period.

Even the specialties that produced the fewest overall AI publications, like Plastic Surgery, Otolaryngology, and Dermatology, demonstrated modest annual growth over the study period. The United States was a leader in AI publications, publishing 48% of the total articles (31,216 of 64,648). Our analysis found that England, publishing 16,759 articles, the Netherlands, with 5,361, and Germany, with 4,657, were also significant publishers of medical AI research (Table 1). An analysis of publication trends in radiology demonstrated the rapid growth of AI publications originating from China and producing the second highest number of radiology AI publications from 2000-2018, however this trend was not reflected in our study [9,10]. This could

suggest that a larger proportion of AI research from China is related to radiology, however it may also be secondary to our use of PubMed for data collection, as opposed to the Web of Science database.

Pathology and Radiology, as leaders in medical AI research and publication, can use their experience to support medical AI research in other specialties. Applications of digital imaging and informatics are well suited to Pathology and Radiology, but other applications such as natural language processing, diagnostic support tools, and triaging of urgent findings are applicable across specialties [11,12]. Physicians with AI expertise can serve as leaders in their own practice, hospital, or hospital network, as well as advocate for safe and intentional integration of clinical AI.

A limitation of our study is the likely underestimation of the total AI related publications during the study period. The literature search was performed on PubMed, and journals not indexed on PubMed would not have been identified. Another limitation comes from search term optimization. The extensive search string used in the data collection encompassed several notable and well-known AI related terms, but the list was not comprehensive. Relevant articles that did not include terms in this search string would not have been identified. This search string also would not have identified foreign language AI articles unless they had included English terms. It is likely that the number of "Pathology" articles was overestimated; articles that use the term "pathology" in their title or abstract to refer to a disease or disease process would have been selected for the "Pathology" specialty section, which may have contributed to the large number of "Pathology" articles. Despite this potential margin of error, we believe our bibliometric analysis still provides valuable insight into the comparative trends in AI research across medical specialties.

Conclusion

There has been growth in AI publication across medical specialties over the past two decades. Radiology and Pathology are leaders in AI publication, responsible for nearly half of AI publications from 2000-2020. As AI continues to grow and integrate into clinical practice, AI literacy will likely be a crucial competency for physicians throughout the medical field.

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